Journal of Cardiology 62 (2013) 25–30

ELSEVIER
Journal of Cardiology
journal homepage: www.elsevier.com/locate/jjcc

Original article

Characteristics of heart failure associated with the Great East Japan Earthquake

Akihiro Nakamura (MD, PhD)[a,*], Hiroyuki Satake (MD)[a], Akiyo Abe (MD)[a], Yuta Kagaya (MD)[a], Katuya Kohzu (MD)[a], Kenjiro Sato (MD)[a], Sohta Nakajima (MD, PhD)[a], Shigefumi Fukui (MD, PhD)[a], Hideaki Endo (MD, PhD)[a], Tohru Takahashi (MD, PhD)[a], Eiji Nozaki (MD, PhD)[a], Kenji Tamaki (MD, PhD)[b]

[a] *Division of Cardiology, Iwate Prefectural Central Hospital, Morioka, Iwate, Japan*
[b] *Division of Cardiology, Iwate Prefectural Miyako Hospital, Miyako, Iwate, Japan*

ARTICLE INFO

Article history:
Received 2 December 2012
Received in revised form 16 January 2013
Accepted 14 February 2013
Available online 25 April 2013

Keywords:
Heart failure
Stress
Earthquake
Japan

ABSTRACT

Background: On March 11, 2011, the Tohoku district was struck by the most powerful known earthquake to hit Japan. Although stress-induced heart diseases rise after strong psychosocial stress, little is known about the characteristics of heart failure (HF) caused by psychosocial stress related to earthquakes.
Methods: We examined patients admitted to our hospital for HF during a three-week period between March 11 and March 31, 2011 (Disaster group) and compared them to patients during the corresponding period of 2010 (Non-Disaster group).
Results: The number of patients was larger in the Disaster group ($n = 30$, 18 men, 12 women; mean age 77.3 ± 9.8 years) than in the Non-Disaster group ($n = 16$, 8 men, 8 women; mean age 77.3 ± 11.6 years). A total of 14 of 30 patients (46.7%) in the Disaster group did not have past history of admission for HF, compared to 2 patients (12.5%) in the Non-Disaster group ($p = 0.02$). The number of patients with hypertension was larger in the Disaster group than in the Non-Disaster group (53.3% vs. 37.5%, $p = 0.04$). The number of patients with atrial fibrillation was also larger in the Disaster group than in the Non-Disaster group (56.7% vs. 25.0%, $p = 0.03$). Left ventricular systolic ejection fraction (EF) did not differ between the Disaster and Non-Disaster groups (45.2 ± 17.8% vs. 45.6 ± 14.0%, $p = 0.46$), however, the proportion of patients whose EF was more than 45% were significantly higher in the Disaster group more than in the Non-Disaster group (56.7% vs. 43.8%, $p = 0.04$). The in-hospital mortality rate for patients in the Disaster group was higher than in the Non-Disaster group (20.0% vs. 6.3%, $p = 0.04$).
Conclusion: The incidence and in-hospital mortality rate of HF increased after the Great East Japan Earthquake, suggesting that psychosocial stress brought on by such a disaster could lead to the development of HF with preserved EF more than that with reduced EF.

Introduction

On March 11, 2011, at 14:46, an earthquake of magnitude 9.0 (Richter scale) occurred on the Pacific coast of Tohoku district, northeastern area of Japan. It was the most powerful known earthquake ever to have hit Japan, and one of the five most powerful earthquakes in the world overall since modern record-keeping began in 1900 [1]. This earthquake triggered powerful tsunami waves, which reached heights of up to 40.5 m (133 ft) in Miyako City in Tohoku's Iwate Prefecture. More than 15,000 people were killed and many buildings were damaged. Iwate Prefectural Central Hospital is located in the center of Iwate Prefecture, and has given high-quality cardiovascular research and medical service for the people who live on the Pacific coast of the Tohoku area. By means of connecting with all other clinics and hospitals in Iwate Prefecture by a medical network system, our hospital has played a central role in the treatment of cardiovascular diseases. After the earthquake, the local residents did not have the option of seeking medical treatment elsewhere or leaving this area. Fortunately, our hospital did not sustain any serious damage and we were able to continue providing medical service as usual.

Kloner et al. [2] reported that both the incidence and mortality rates of cardiovascular disease increased in the week following the Los Angeles earthquake in 1994. Kario et al. [3] also showed the incidence of cardiovascular disease increased markedly after the Great Hanshin-Awaji earthquake. Thus, several studies demonstrate increased cardiovascular disease after acute psychosocial stress such as the great earthquake, however, little is known about more detailed information for heart failure (HF) caused by

* Corresponding author at: Division of Cardiology, Iwate Prefectural Central Hospital, Morioka, Iwate 020-0061, Japan. Tel.: +81 019 653 1151; fax: +81 019 653 2528.
E-mail addresses: AkihiroNakamura0223@msn.com, akihiro-nakamura@pref.iwate.jp (A. Nakamura).

0914-5087/$ – see front matter © 2013 Published by Elsevier Ltd on behalf of Japanese College of Cardiology.
http://dx.doi.org/10.1016/j.jjcc.2013.02.015

psychosocial stress. In this study, we focused on HF caused by psychosocial stress and investigated the incidence, the mortality rate, and characteristics of HF related with the Great East Japan Earthquake.

Methods

Study population

We consecutively enrolled 30 patients (18 men, 12 women; mean age 77.3 ± 9.8 years) who were admitted to Iwate Prefectural Central Hospital, Morioka, Japan for acute HF during the three-week period between March 11 and March 31, 2011 (Disaster group), and compared them to 16 patients (8 men, 8 women; mean age 77.3 ± 11.6 years) with acute HF during the corresponding period of 2010 (Non-Disaster group). This investigation was conducted according to the principles expressed in the Declaration of Helsinki, and the study was approved by the Regional Ethics Committee and bureau of protection of personal privacy.

Diagnosis of HF

The diagnosis of HF was made by at least 2 senior cardiologists using the generally accepted Framingham criteria [4] and other relevant information, including a history of dyspnea and symptomatic exercise intolerance with signs of pulmonary congestion or peripheral edema, the presence of moist rales on auscultation, or documentation of left ventricular (LV) enlargement or dysfunction by chest X-ray or echocardiography. LV function was assessed by the American College of Cardiology/American Heart Association and European Society of Cardiology guidelines [5,6]. Diagnoses of hypertension, diabetes mellitus, and hyperlipidemia were obtained from medical records or patient histories of current or previous medical therapy. Patients with no history of atrial fibrillation (AF), and who did not show AF on continuous electrocardiographic monitoring during hospitalization, were defined as patients with sinus rhythm, and patients with transient and chronic AF were defined as AF patients.

Laboratory examinations and collection of clinical data

Routine blood chemistry and hematology tests were performed at admission. The plasma B-type natriuretic peptide (BNP) levels were measured by using a commercially available specific radioimmunoassay (Shiono RIA BNP assay kit; Shionogi Co., Tokyo, Japan) [7,8]. Clinical data, including age, gender, and body mass index were obtained from hospital medical records and patient interviews.

Echocardiography

Transthoracic echocardiographic measurements were performed soon after admission using standard methods by two independent, experienced echocardiographers who had no knowledge of this study and who performed all measurements. LV end-diastolic volume, end-systolic volume, and ejection fraction (EF) were calculated using the modified Simpson method [9]. We assumed preserved EF with an LVEF ≥45% [10,11]. Patterns of diastolic dysfunction were determined by mitral inflow E/A ratios of peak velocities at early rapid filling (E) and late filling from atrial contraction (A), and deceleration time (DcT) of the E wave of Doppler mitral inflow was also measured as an indicator of LV diastolic function.

Therapy of HF after admission

Patients were treated with intravenous atrial natriuretic peptide (ANP) [12,13], a circulating hormone of cardiac origin which has vasodilator and diuretic properties and can inhibit the renin–angiotensin–aldosterone system and/or low-dose dopamine in addition to optimal standard therapy including β-adrenergic antagonists, angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers, and aldosterone antagonists. Diuretics were administered in flexible doses on the basis of body weight and daily dieresis. The indications for ANP, dopamine, or diuretics administration were determined by 2 senior cardiologists. After acute phase, patients were treated orally with optimal pharmacologic drugs including β-adrenergic antagonists, angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers, aldosterone antagonists, and diuretics.

Definition of cardiovascular death

We evaluated all-cause death and cardiovascular death during hospitalization. Cardiovascular death was defined as heart failure-related death, stroke-related death, myocardial infarction, or arrhythmia-related death and sudden death.

Statistical analysis

We examined the magnitude of increased risk of HF before and after the earthquake on 11 March 2011 and in corresponding periods in previous years or 2012 as previously reported by Dobson et al. [14]. Data are presented in 2 × 2 tables as follows: the number of patients with HF before the earthquake (February 18 to March 10, 2011) was shown as A, and that with HF after the earthquake (March 11 to March 31, 2011) was shown as B. The number of patients with HF during the period of February 18 to March 10, 2012 or previous years (2009, 2010) is shown as C, and that with HF during the period of March 11 to March 31, 2012 or previous years (2009, 2010) is shown as D. A proportion of events in 2011 as B/A was compared with the corresponding proportions in 2012 or previous years (2009, 2010), D/C. Results are presented by the odds ratio (OR): OR = (B/A)/(D/C).

All values are expressed as mean ± standard deviation for continuous variables and as numbers and percentages for categorical variables. Unpaired Student's *t* test was used to compare continuous variables. If data were not distributed normally, the Mann–Whitney *U*-test was used. The chi-square test or Fisher's exact test was used for categorical variables. A *p*-value of <0.05 was considered to be statistically significant. All statistical analyses were performed using a commercially available statistical software: JMP version 9.0 (SAS, Institute Inc., Cary, NC, USA).

Results

Number of HF patients

The total number of patients who were admitted to our hospital (Fig. 1) for HF during the three-week period between March 11 and March 31, 2011 was 30 (Disaster group), whereas that during the corresponding period of 2010 was 16 (Non-Disaster group). The number of patients in the Disaster group increased by about twofold (Fig. 2). Six of thirty patients (20%) in the Disaster group were residents of the coastal area which was affected by the tsunami and two patients were tsunami survivors.

Compared with 2010 or 2009, OR for HF during the three-week period in 2011 was 1.52 [95% confidence interval (CI): 1.32–3.93] and 2.66 (95% CI: 1.02–6.92), respectively. When compared with

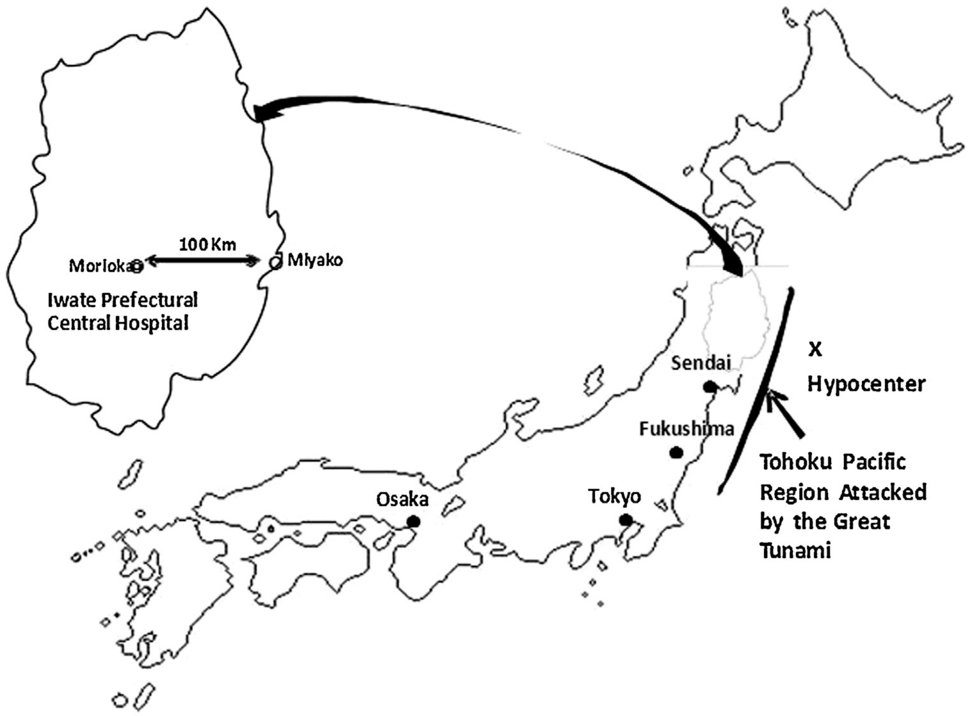

Fig. 1. The Great East Japan Earthquake and location of our hospital. Iwate Prefectural Central Hospital is located in Morioka City, in the center of Iwate Prefecture.

2009, OR for HF during the three-week period in 2010 was 1.74 (95% CI: 0.62–4.92) (Table 1).

Comparison of characteristics between the Disaster and Non-Disaster groups

Patient characteristics of the Disaster and Non-Disaster groups are shown in Table 2. There was no difference in age and body mass indexes between patients in the Disaster and Non-Disaster groups. The etiology of HF in the Disaster group was hypertensive heart disease in 10 patients (33.3%), ischemic heart disease in 10 patients (33.3%), valvular heart disease in 6 patients (20.0%), dilated cardiomyopathy in 2 patients (6.7%), and other causes in 2 patients (6.7%), whereas it was hypertensive heart disease in 5 patients (31.3%), ischemic heart disease in 7 patients (43.8%), valvular heart disease in 2 patients (12.5%), and other causes in 2 patients (12.5%) in the Non-Disaster group. The prevalence of hypertension was significantly higher in patients in the Disaster group than those in the Non-Disaster group (53.3% vs. 37.5%, $p = 0.04$), however, there was no difference in the prevalence of diabetes mellitus or dyslipidemia between the two groups. There was no difference in etiology of HF between patients in the Disaster and Non-Disaster groups. In the Disaster group, the number of patients with atrial fibrillation was significantly larger than in the Non-Disaster group (56.7% vs. 25.0%, $p = 0.03$). A total of 14 of 30 patients (46.7%) in the Disaster group showed initial HF hospitalization, whereas there were only 2 patients (12.5%) in the Non-Disaster group ($p = 0.02$). In-hospital mortality rate for patients in the Disaster group was significantly higher than that in the Non-Disaster group (20.0% vs. 6.3%, $p = 0.04$). There was a tendency for a higher level of plasma BNP in the Disaster group when compared with that of the Non-Disaster group, however, there was no significant difference between the two groups (1138 ± 1007 vs. 797 pg/dl ± 607 pg/dl, $p = 0.31$). There was no difference in baseline therapy on admission between patients in the Disaster and Non-Disaster groups.

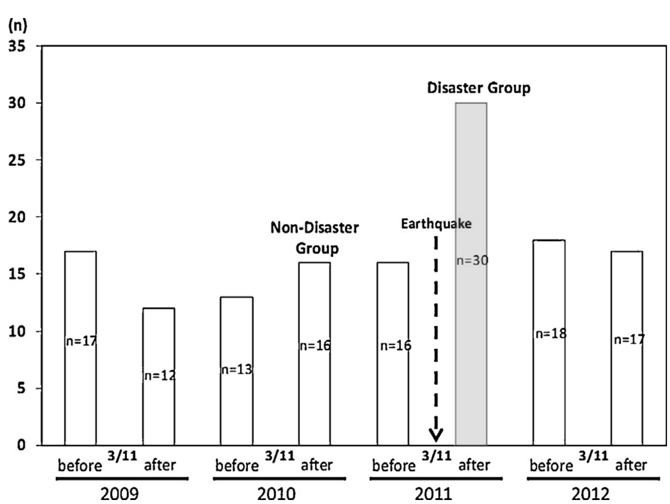

Fig. 2. Number of heart failure (HF) patients during the three-week period before and after March 11 from 2009 to 2011.

Table 1
Number of HF patients during three weeks before and after the earthquake in 2011 and previous years, with odds ratio and 95% confidence interval.

	Feb. 18 to Mar. 10	Mar. 11 to Mar. 31	OR	95% CI
2011	16	30	1.52	1.32–3.93
2010	13	16		
2011	16	30	2.66	1.02–6.92
2009	17	12		
2010	13	16	1.74	0.62–4.92
2009	17	12		

Data are expressed as number, odds ratio (OR) and 95% confidence interval (CI). HR, heart failure; Feb, February; Mar, March.

Table 2
Clinical characteristics.

Variable	Disaster group ($n = 30$)	Non-Disaster group ($n = 16$)	p-Value
Age (years)	77.3 ± 9.8	77.3 ± 11.6	0.49
Men, n (%)	18 (60.0%)	8 (50.0%)	0.20
Body mass index (kg/m^2)	21.1 ± 2.9	20.3 ± 2.0	0.19
Hypertension, n (%)	16 (53.3%)	6 (37.5%)	0.04
Diabetes mellitus, n (%)	7 (23.3%)	6 (37.5%)	0.68
Dyslipidemia, n (%)	5 (16.7%)	5 (31.3%)	0.28
eGFR (ml/min/1.73 m^2)	58.4 ± 10.6	44.1 ± 14.3	0.06
Etiology of HF			
Hypertensive heart disease, n (%)	10 (33.3%)	5 (31.3%)	0.77
Ischemic heart disease, n (%)	10 (33.3%)	7 (43.8%)	0.53
Valvular heart disease, n (%)	6 (20.0%)	2 (12.5%)	0.69
Dilated cardiomyopathy, n (%)	2 (6.7%)	0 (0.0%)	0.29
Others, n (%)	2 (6.7%)	2 (12.5%)	0.50
Atrial fibrillation, n (%)	17 (56.7%)	4 (25.0%)	0.03
Smokers, n (%)	5 (16.7%)	3 (18.8%)	0.85
Heart rate (beats/min)	97.8 ± 25.1	85.3 ± 18.1	0.06
Systolic blood pressure (mmHg)	149.9 ± 36.3	122.6 ± 26.0	0.01
Diastolic blood pressure (mmHg)	81.9 ± 21.5	72.4 ± 15.5	0.08
Initial HF hospitalization, n (%)	14 (46.7%)	2 (12.5%)	0.02
In-hospital mortality rate, n (%)	6 (20.0%)	1 (6.3%)	0.04
BNP (pg/dl)	1138 ± 1007	797 ± 607	0.31
Baseline therapy			
ACE-I or ARB, n (%)	13 (43.3%)	7 (43.8%)	0.98
β-Blockers, n (%)	11 (36.7%)	16 (37.5%)	0.75
Loop diuretics, n (%)	12 (40.0%)	7 (43.8%)	0.86
Spironolactone, n (%)	4 (13.3%)	3 (18.9%)	0.36

Data are expressed as number of patients (%) or mean ± SD. eGFR, estimated glomerular filtration rate; HF, heart failure; BNP, brain natriuretic peptide, ACE-I, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker.

Comparison of echocardiographic parameters between the Disaster and Non-Disaster groups

Table 3 shows echocardiographic parameters of patients in the Disaster group and those in the Non-Disaster group. LV systolic function did not differ between the Disaster and Non-Disaster groups (LVEF: 45.2 ± 17.8% vs. 45.6 ± 14.0%, $p = 0.46$), however, the proportion of patients whose EF was more than 45% were significantly higher in the Disaster group than in the Non-Disaster group (56.7% vs. 43.8%, $p = 0.04$). There was no difference in LV wall thickness, left atrial dimension, and parameters for LV diastolic function such as E/A ratio and deceleration time of E wave between the two groups.

Table 3
Comparison of echocardiographic parameters between patients in Disaster and Non-Disaster group.

Parameters	Disaster group ($n = 30$)	Non-Disaster group ($n = 16$)	p-Value
LV end-diastolic dimension (mm)	47.8 ± 7.1	53.5 ± 3.9	0.28
LV end-systolic dimension (mm)	36.4 ± 8.5	41.7 ± 6.2	0.17
LV EF (%)			
EF ≧ 45%, n (%)	17 (56.7%)	7 (43.8%)	0.04
LV interventricular septal thickness			
At end-diastole (mm)	12.0 ± 2.8	11.2 ± 2.7	0.30
LV posterior wall thickness			
At end-diastole (mm)	12.2 ± 3.0	11.7 ± 1.3	0.28
Left atrial dimension (mm)	42.5 ± 10.0	48.0 ± 7.0	0.13
E/A ratio	1.60 ± 0.7	1.58 ± 0.6	0.43
Deceleration time of E wave (ms)	172.7 ± 68.4	158.7 ± 74.0	0.39

Data are expressed as number of patients (%) or mean ± SD. LV, left ventricular; EF, ejection fraction; E, peak early diastolic flow velocity of transmitral flow velocity curve; A, peak velocity of transmitral flow velocity curve at atrial contraction.

Comparison of characteristics between HF patients with preserved and reduced EF in the Disaster and Non-Disaster groups

Table 4 shows the comparison of patients' characteristics between HF with preserved EF (≥45%) and reduced EF (<45%) in the Disaster group. Patients with preserved EF showed that the prevalence of men, initial HF hospitalization, hypertension, and ischemic heart disease was significantly higher in patients in the Disaster group than those in Non-Disaster group. Table 5 showed the comparison of patients' characteristics between HF with preserved EF and HF with reduced EF in the Non-Disaster group. There was no significant difference in the prevalence of men, initial HF hospitalization, atrial fibrillation, hypertension, diabetes mellitus, and ischemic heart disease.

Comparison of the mortality rate between the Disaster and Non-Disaster groups

A total of 6 of 30 patients (20%) in the Disaster group died during hospitalization, whereas there was only 1 patient (6.3%) in the Non-Disaster group who died ($p = 0.04$). All-cause mortality was significantly higher in the Disaster group than in the Non-Disaster group.

In the Disaster group, 4 of 6 patients died due to cardiovascular death (3 heart failure-related death; 1 sudden death due to severe aortic valve stenosis), and 2 patients died due to non-cardiovascular death (1 sepsis; 1 pulmonary embolism). Two of six dead patients showed HF with preserved EF and 4 patients showed HF with reduced EF.

In the Non-Disaster group, the cause of death was pneumonia and this patient showed HF with reduced EF.

Discussion

The major findings of the present study are that the incidence and in-hospital mortality rate of HF increased, and the patients who showed HF with preserved EF increased after the Great East Japan Earthquake. Although there have been several studies on cardiovascular events such as sudden cardiac death and acute myocardial

Table 4
Comparison of clinical characteristics between patients with HFpEF and HFrEF in Disaster group.

Variable	HFpEF ($n = 17$)	HFrEF ($n = 13$)	p-Value
Age (years)	80.2 ± 9.1	75.4 ± 11.1	0.22
Men, n (%)	7 (41.2%)	11 (69.9%)	0.04
Initial HF hospitalization, n (%)	11 (64.7%)	3 (23.1%)	0.02
Atrial fibrillation, n (%)	10 (58.8%)	7 (53.8%)	0.87
Hypertension, n (%)	11 (64.7%)	5 (38.5%)	0.04
Diabetes mellitus, n (%)	4 (23.5%)	3 (23.1%)	0.96
Ischemic heart disease, n (%)	3 (17.6%)	7 (53.8%)	0.03

Data are expressed as number of patients (%) or mean ± SD. HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure reduced ejection fraction.

Table 5
Comparison of clinical characteristics between patients with HFpEF and HFrEF in Non-Disaster group.

Variable	HFpEF ($n = 7$)	HFrEF ($n = 9$)	p-Value
Age (years)	77.7 ± 16.7	78.0 ± 8.3	0.97
Men, n (%)	3 (42.9%)	5 (55.6%)	0.62
Initial HF hospitalization, n (%)	1 (14.3%)	1 (11.1%)	0.85
Atrial fibrillation, n (%)	2 (28.6%)	2 (22.2%)	0.26
Hypertension, n (%)	3 (42.9%)	3 (33.3%)	0.76
Diabetes mellitus, n (%)	3 (42.9%)	3 (33.3%)	0.76
Ischemic heart disease, n (%)	1 (14.3%)	6 (66.7%)	0.41

Data are expressed as number of patients (%) or mean ± SD. HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure reduced ejection fraction.

infarction after great disasters, there is little information on HF caused by sudden psychosocial stress such as an earthquake.

Victims of the great earthquake are vulnerable to stress and anxiety which can exacerbate existing medical conditions such as cardiovascular disease and ischemic heart disease [2,3]. The sudden psychosocial stress brought about by the earthquake is thought to be an important precipitating factor, since activation of the sympathetic nervous system and catecholamine release during the stress may enhance vascular spasm, injury, formation of platelet-rich thrombi, and potential subsequent rupture of a vulnerable atherosclerotic plaque.

It has been believed that the incidence or mortality rates of cardiovascular disease often significantly increase in the weeks following an earthquake. In the week following the Los Angeles earthquake in 1994, mortality rates from cardiovascular disease increased and then rapidly decreased a week later to levels lower than normal [2]. Kario et al. [15] reported that great earthquakes increase the incidence of death by cardiovascular disease during the period from night-time to morning, especially among the elderly living near the epicenter. Ogawa et al. [16] reported that the standardized mortality rate of acute myocardial infarction significantly increased about eight weeks after the Great Hanshin-Awaji earthquake. Leor et al. [17] also reported a significant increase in the number of admissions for myocardial infarction during the week after the 1994 Northridge earthquake. Thus, there were previous studies from Japan or other countries showing the increase of cardiovascular events, whereas Dobson et al. [14] reviewed data from hospital in the area of the 1989 Newcastle earthquake and reported that relative risk for myocardial infarction in the 4 days after the earthquake was not statistically significantly different. Our observation is compatible with the concept that the onset of cardiovascular events may be related to certain triggers and that the psychosocial stress might be a trigger. However, we need further investigation focused on HF after the great earthquake because of the small number of patients in our study.

In the present study, we defined LVEF $\geq$45% as HF with preserved EF, because there is no consensus regarding the cutoff for preserved EF and it was variably defined as an LVEF $\geq$40%, $\geq$45%, or $\geq$50% [10,11,18–21]. Current guidelines for diagnosis and treatment of HF require the presence of normal or mildly abnormal LVEF ($\geq$45–50%) for the diagnosis of HF with preserved EF [5].

Of particular interest, we observed that the proportion of patients with preserved LVEF ($\geq$45%) in the Disaster group was significantly higher than that in the Non-Disaster group, and the prevalence of hypertension was significantly higher in patients in the Disaster group than those in the Non-Disaster group. The sudden psychosocial stress brought about by the earthquake increases blood pressure, and then the heart afterload secondary to hypertension leads to an increase in LV wall tension and wall stress. Heightened blood pressure and the sympathetic nervous system and/or the renin–angiotensin–aldosterone system activity may be a mechanism for hypertension-HF with preserved LVEF link in these patients exposed to stressful conditions.

Loss of medication and medical records caused by the tsunami might interrupt anti-hypertensive medical treatment in patients with hypertension, and uncontrolled hypertension might be one of the causes of HF hospitalization. In the present study, six patients were coastal residents, and two of them were tsunami survivors. Although these two patients had a history of temporary interruption of anti-hypertensive medications just after the disaster, other patients with hypertension could continue medications. Thus, compliance with antihypertensive medications might not be poor due to loss of drugs or insufficient drug supply in association with the disaster. Among many factors associated with increased incidence of HF in disasters, elevated blood pressure is one of the important factors. Our study suggested that elevation of blood pressure due to not only discontinued medication but also other factors which could activate sympathetic nerve system and/or renin–angiotensin–aldosterone system played an important role. Because these systems are also regulating blood volume or heart rate, contribution of augmented preload or increase of heart rate as well as afterload might be likely involved in the increased incidence of HF hospitalization [22–25].

Although our study suggests that disaster-induced psychological stress could develop the diastolic HF with poor prognosis, it is difficult to evaluate psychological stress and its association with HF. Furthermore, physical stress including cold temperature can elevate blood pressure regardless of psychological stress brought on by such a great disaster [26]. At Morioka located in the center of Iwate Prefecture (Fig. 1), the average high and low temperatures recorded during the three-week period between March 11 and March 31, 2011 were 7.2 °C and −2.2 °C, respectively, whereas those during the corresponding period of 2012, 2010, and 2009 were 6.5 °C and −1.3 °C, 5.9 °C and −1.5 °C, and 7.5 °C and −0.6 °C, respectively. There were no differences in the average high and low temperatures during the three-week period between March 11 and March 31 in 2011 and 2010, 2009, or 2012.

According to the study that investigated the effect of tremendous psychological stress on blood pressure in the Hanshin-Awaji earthquake, the blood pressure increased significantly for the patients who were living in the area of the very severe earthquake during the 4 weeks after the earthquake. However, the increase in blood pressure peaked in the first week, declined thereafter, and returned to the baseline within 6 weeks after the disaster. This earthquake-related blood pressure elevation was significantly attenuated in patients receiving β-blockers compared with those receiving other drugs [27]. Therefore, early treatment with β-blockers, angiotensin-converting enzyme inhibitors, or angiotensin receptor blockers that affect certain aspects of these changes may be useful for the prevention of HF with preserved LVEF.

Limitations of our study

The present study had several limitations. First, this was a single-center retrospective observational study. Second, the number of study subjects was not large. Third, in the present study, severity of the psychosocial stress was impossible to quantitate. Suzuki et al. [28] reported that emotional stress level increased after the Great Hanshin-Awaji earthquake by using the post-traumatic stress disorder reaction index score, and showed that severe emotional stress such as an earthquake could trigger acute myocardial infarction. Quantitative examination for stress after the great earthquake might provide more important information concerning the causal relationship between psychosocial stress and HF. Fourth, LV dysfunction was determined using echocardiography, and no direct invasive hemodynamic measurements of LV diastolic dysfunction were performed.

Conclusion

Our study showed an increase in the number of patients with HF during the week after the Great East Japan Earthquake, and that hospital and emergency services should have contingency plans for an increase in HF patients following an earthquake.

Conflict of interest

None declared.

References

[1] Simons M, Minson SE, Sladen A, Ortega F, Jiang J, Owen SE, Meng L, Ampuero J-P, Wei S, Chu R, Helmberger DV, Kanamori H, Hetland E, Moore AW, Webb FH. The 2011 magnitude 9.0 Tohoku-Oki earthquake: mosaicking the megathrust from seconds to centuries. Science 2011;332:1421–5.
[2] Kloner RA, Leor J, Poole WK, Perritt R. Population-based analysis of the effect of the Northridge earthquake on cardiac death in Los Angeles county, California. J Am Coll Cardiol 1997;30:1174–80.
[3] Kario K, Matsuo T, Kobayashi H, Yamamoto K, Shimada K. Earthquake-induced potentiation of acute risk factors in hypertensive elderly patients: possible triggers of cardiovascular events after a major earthquake. J Am Coll Cardiol 1997;29:926–33.
[4] McKee P, Castelli W, McNamara PM, Kannel WB. The natural history of congestive heart failure: the Framingham study. N Engl J Med 1971;285:1441–6.
[5] Dickstein K, Cohen-Solal A, Filippatos G, McMurray JJ, Ponikowski P, Poole-Wilson PA, Stromberg A, Van Veldhuisen DJ, Atar D, Hoes AW, Keren A, Mebazaa A, Nieminen M, Priori SG, Swedberg K. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2008: the task force for the diagnosis and treatment of acute and chronic heart failure 2008 of the European Society of Cardiology, Developed in collaboration with the Heart Failure Association of the ESC (HFA) and endorsed by the European Society of Intensive Care Medicine (MSICM). Eur J Heart Fail 2008;10: 933–89.
[6] Hunt SA, Abraham WT, Chin MH, Feldman AM, Francis GS, Ganiats TG, Jessup M, Konstam MA, Mancini DM, Michl K, Oates JA, Rahko PS, Silver MA, Stevenson LW, Yancy CW, et al. ACC/AHA 2005 Guideline Update for the Diagnosis and Management of Chronic Heart Failure in the Adult: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Update the 2001 Guidelines for the Evaluation and Management of Heart Failure): developed in collaboration with the American College of Chest Physicians and the International Society for Heart and Lung Transplantation: endorsed by the Heart Rhythm Society. Circulation 2005;112:e154–235.
[7] Rawlins ML, Owen WE, Roberts WL. Performance characteristics of four automated natriuretic peptide assays. Am J Clin Pathol 2005;123: 439–45.
[8] Matsuo S, Nakae I, Tsutamoto T, Okamoto N, Horie A. A novel clinical indicator using Tc-99m sestamibi for evaluating cardiac mitochondrial function in patients with cardiomyopathies. J Nucl Cardiol 2007;14: 215–20.
[9] Schiller NB, Shah PM, Crawford M, De Maria A, Devereux R, Feigenbaum H, Gutgesell H, Reicheck N, Sahn D, Schnittger I, Silverman NH, Tajik AJ. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. J Am Soc Ecocardiogr 1989;2:358–67.
[10] Massie BM, Carson PE, McMurray JJ, Komajda M, McKelvie R, Zile MR, Anderson S, Donovan M, Iverson E, Staiger C, Ptaszynska A, I-PRESERVE Investigators. Irbesartan in patients with heart failure and preserved ejection fraction. N Engl J Med 2008;359:2456–67.
[11] Lee DS, Gona P, Vasan RS, Larson MG, Benjamin EJ, Wang TJ, Tu JV, Levy D. Relation of disease pathogenesis and risk factors to heart failure with preserved or reduced ejection fraction: insights from the Framingham Heart Study of the National Heart, Lung, and Blood Institute. Circulation 2009;119:3070–7.
[12] Kitashiro S, Sugiura T, Takayama Y, Tsuka Y, Izuoka T, Tokunaga S, Iwasaka T. Long-term administration of atrial natriuretic peptide in patients with acute heart failure. J Cardiovasc Pharmacol 1999;33:948–52.
[13] Brunner-La Rocca HP, Kiowski W, Ramsay D, Sütsch G. Therapeutic benefits of increasing natriuretic peptide levels. Cardiovasc Res 2001;51:510–20.
[14] Dobson AJ, Alexander HM, Malcolm JA, Steele PL, Miles TA. Health attacks and the Newcastle earthquake. Med J Aust 1991;155:757–61.
[15] Kario K, Matsuo T, Kayaba K, Soukejima S, Shimada K. Earthquake-induced cardiovascular disease and related risk factors in focusing on the Great Hanshin-Awaji earthquake. J Epidemiol 1998;8:131–9.
[16] Ogawa K, Tsuji I, Shiono K, Hisamichi S. Increased acute myocardial infarction mortality following the 1995 Great Hanshin-Awaji earthquake in Japan. Int J Epidemiol 2000;29:449–55.
[17] Leor J, Kloner RA. The Northridge earthquake as a trigger for acute myocardial infarction. Am J Cardiol 1996;77:1230–3.
[18] Gaasch WH. Diagnosis and treatment of heart failure based on left ventricular systolic or diastolic dysfunction. JAMA 1994;271:1276e80.
[19] Smith GL, Masoudi FA, Vaccarino V, Radford MJ, Krumholz HM. Outcomes in heart failure patients with preserved ejection fraction: mortality, readmission, and functional decline. J Am Coll Cardiol 2003;41:1510e8.
[20] Satomura H, Wada H, Sakakura K, Kubo N, Ikeda N, Sugawara Y, Ako J, Momomura S. Congestive heart failure in the elderly: comparison between reduced ejection fraction and preserved ejection fraction. J Cardiol 2012;59:215–9.
[21] Kutsuzawa D, Arimoto T, Watanabe T, Shishido T, Miyamoto T, Miyashita T, Takahashi H, Niizeki T, Takeishi Y, Kubota I. Ongoing myocardial damage in patients with heart failure and preserved ejection fraction. J Cardiol 2012;60:454–61.
[22] Aoki T, Fukumoto Y, Yasuda S, Sakata Y, Ito K, Takahashi J, Miyata S, Tsuji I, Shimokawa H. The Great East Japan earthquake disaster and cardiovascular diseases. Eur Heart J 2012;33:2796–803.
[23] Kario K. Disaster hypertension—its characteristics, mechanism, and management. Circ J 2012;76:553–62.
[24] Dimsdale JE. Psychological stress and cardiovascular disease. J Am Coll Cardiol 2008;51:1237–46.
[25] Schwartz BG, French WJ, Mayeda GS, Burstein S, Economides C, Bhandari AK, Cannom DS, Kloner RA. Emotional stressors trigger cardiovascular events. Int J Clin Pract 2012;66:631–9.
[26] Cheng X, Su H. Effects of climatic temperature stress on cardiovascular disease. Eur J Intern Med 2010;21:164–7.
[27] Saito K, Kim J, Maekawa II, Ikeda K, Yokoyama YM. The great Hansin-Awaji earthquake aggravates blood pressure control in treated hypertensive patients. Am J Hypertens 1997;10:217–21.
[28] Suzuki S, Sakamoto S, Koide M, Fujita H, Sakuramoto H, Kuroda T, Kintaka T, Matsuo T. Hanshin-Awaji earthquake as a trigger for acute myocardial infarction. Am Heart J 1997;134:974–7.